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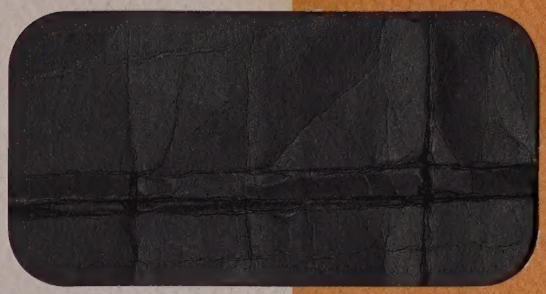

GENERAL ELECTRIC CO.
Instrumentation & Control
228 W. Florence Ave.
Inglewood, Calif. 90301

INSTRUCTION MANUAL

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INSTRUCTION MANUAL

VOLTAGE REGULATED
POWER SUPPLY

MODEL KS 8-100 A

SERIAL NO. C 34000

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1-1 DESCRIPTION AND SPECIFICATIONS

The Model KS is a high current, voltage regulated DC Power Supply that has both adjustable output voltage and adjustable maximum current output. It employs power transistors as series pass elements, in a feedback controlled, closed loop series regulating system. Controlled silicon rectifiers are used to produce DC power for the output. These are controlled to pre-regulate the DC power, and to automatically vary the voltage input to the series regulator so as to maintain an essentially constant voltage drop across the series regulator elements. The KS units are fully programmable for automatic or remote operation. They have internal forced-air cooling fans, and are rated for continuous duty at any output in their specified range.

....DC OUTPUT: 0 to 8 volts, continuously adjustable; 0 to 100 amperes.

....AC INPUT REQUIREMENTS: 104/115/208/230 volts, 50-65 cps single phase; 1800 watts; 24 amperes at 125 volts.

....LINE REGULATION: For 115-volt operation, less than 0.01% for 105-125 volts AC line change, at any output voltage in the specified range. For 104-, 208-, or 230-volt operation, less than 0.01% for changes of 94-114 volts, 188-228 volts, and 210-250 volts, respectively.

....LOAD REGULATION: 0.01% or 0.001 volts, whichever is greater, for a change in load from no-load to full-load, at any output voltage in the specified range.

....RIPPLE: Less than 0.001 volt, rms.

....STABILITY: Output voltage change is less than 0.01% or 0.003 volts, whichever is greater, over 8 hours at constant ambient temperature.

....OUTPUT IMPEDANCE: Less than 0.0002 ohms, DC to 1 KC; 0.02 ohms, 1 KC to 10 KC; 0.1 ohms, 10 KC to 100 KC.

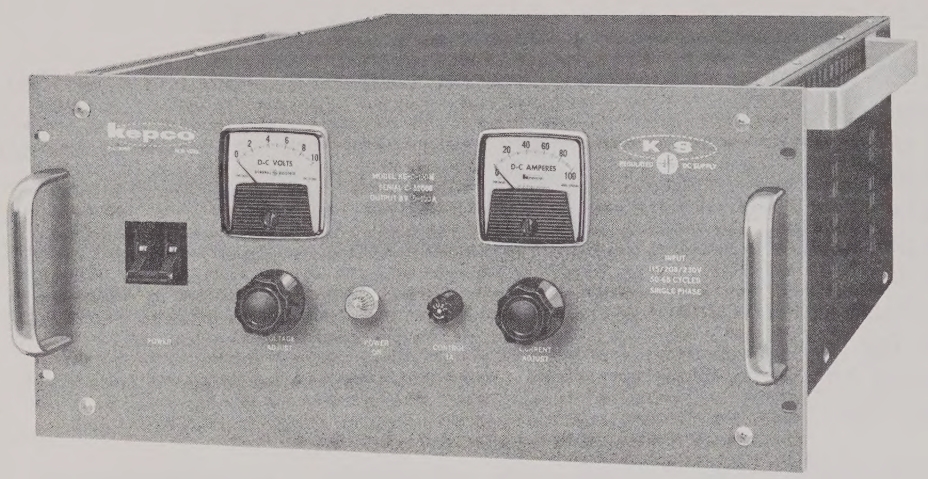
....RECOVERY TIME: 50 microseconds.

....AMBIENT OPERATING TEMPERATURE: -20 to +50C.

....TEMPERATURE COEFFICIENT: Output voltage changes less than 0.01% per degree C, within the specified ambient temperature range.

....DIMENSIONS: Height 8-3/4 inches; Width 19 inches; Depth 20 inches; (behind front panel).

....WEIGHT: 145 pounds.



1-2 TERMINALS AND CONTROLS

....POWER. - Circuit Breaker switch turns power on. Pilot light on front panel indicates when power is on.

....FUSE. - Fuse marked Control, on front panel, protects input to auxiliary power transformer supplying all internal circuit voltages other than the main DC power circuit.

....VOLTAGE ADJUST. - Ten-turn control on front panel for setting the output voltage.

....MAXIMUM CURRENT ADJUST. - Ten-turn control on front panel for setting the adjustable current limiting function.

On Back of Unit:

....CONTROL TERMINAL STRIP. - Fourteen-terminal barrier strip for connecting to circuit terminals required for special operating applications.

....GROUNDING TERMINAL. - Flexible terminal with spade lug, located on chassis adjacent to DC terminals, for making ground connection to either side of DC output.

....DC OUTPUT TERMINALS. - Pressure type connectors are provided for the 100 ampere and 50 ampere models. Barrier type terminals are used for the lower current models.

....AC INPUT LINECORD. - Heavy duty flexible, three-wire linecord with grounding plug for connection to AC line. Third wire in cord is grounded to chassis.

1-3 SPECIAL FEATURES

REMOTE ERROR SENSING. - External Error Sensing terminals located on the control terminal strip allow the error sensing of the output voltage to be performed remotely, at the load. This enables the Supply to regulate for voltage drops of up to 0.5 volt in each load wire and thereby provide specified regulation directly at the load.

CONSTANT VOLTAGE/CONSTANT CURRENT OUTPUT. - The output may be operated at either constant regulated voltage or constant current. Maximum Current control on front panel enables setting automatic crossover from constant voltage to constant maximum current, at any current from 0.5% to 100% of the rated maximum current.

CONSTANT CURRENT OPERATION. - By the use of a current sensing and a current control resistor both externally connected, the output can be converted to provide constant current only, through a varying load.

PROGRAMMING BY RESISTANCE. - The output voltage can be programmed or controlled remotely by an externally connected resistance. The externally connected resistance will program the output voltage at a constant resistance-to-voltage ratio of 100 ohms-per-volt over the entire specified range of the unit.

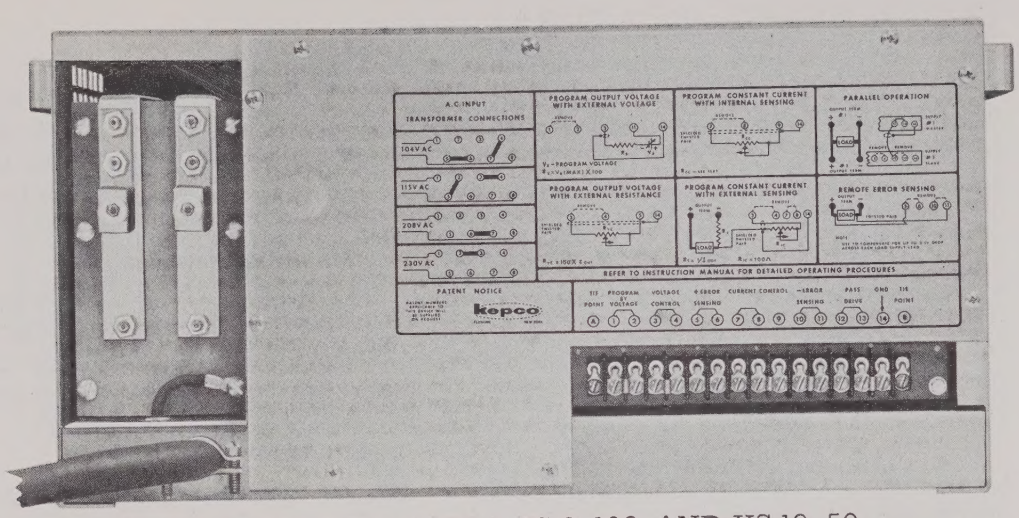
PROGRAMMING BY VOLTAGE. - The output voltage can be programmed by another voltage, for special programming applications such as Complementary Tracking, Compliance Voltage Extension for Constant Current, etc.

PROGRAMMING CURRENT. - The Adjustable Maximum Current function with internal sensing can be programmed by an external source of either voltage or resistance.

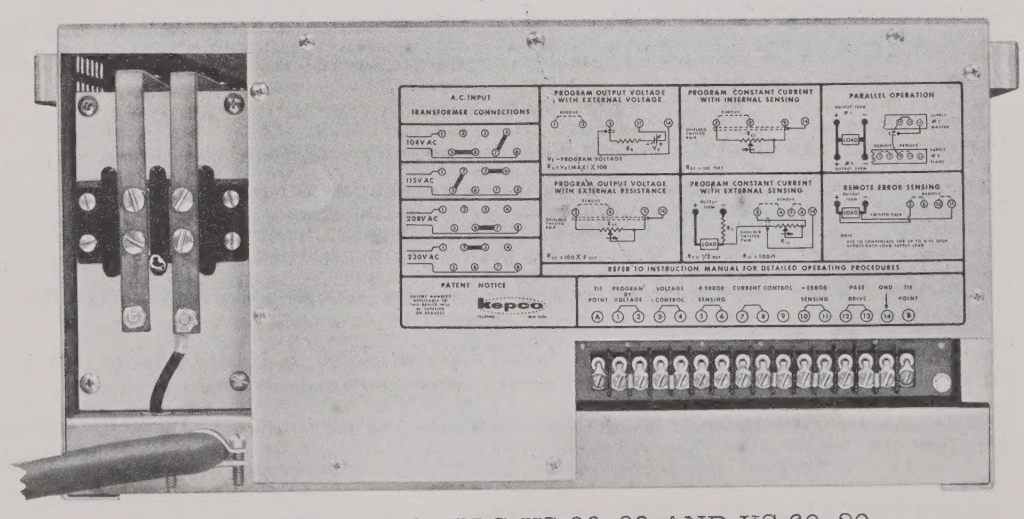
PARALLEL OPERATION. - The output of two KS units of the same type can be connected in parallel across a common load to obtain higher current. Special terminals in the Pass Driver control circuit allow the series Pass elements to be parallel driven by a common control signal, automatically providing equal distribution of the current drawn from each Supply.

OVERLOAD PROTECTION. - Current limiting automatically limits the output current during overload to the value at which the Maximum Current is set. This allows the Supply to continue operating, without damage and without shutting off, during an output overload up to full short circuit.

OVERTEMPERATURE PROTECTION. - Temperature sensing circuit turns Power off if internal overtemperature develops. Manual reset of circuit-breaker switch is required to restore DC output.



REAR VIEW OF MODELS KS 8-100 AND KS 18-50



REAR VIEW OF MODELS KS 36-30 AND KS 60-20

2-1 GENERAL OPERATING INSTRUCTIONS

INSTALLATION. - The KS Power Supply has been completely inspected and tested at the factory prior to packing, and is shipped ready for installation and operation. The unit is equipped with pull handles on the front panel. In addition it is equipped with removable handles on each side and steel skid rails on the bottom to facilitate handling. These may be left in place for bench operation, or can be removed if they interfere with rack installation. They should be stored for re-use if they are removed.

AC POWER INPUT. - The KS Supply is designed so that by moving jumper links connected between different primary terminals of the main power transformer, the unit can be set for operation on either 104, 115, 208, or 230 volts AC.

Unless otherwise specified, the unit is shipped with the transformer terminals connected for 115 volt operation, and the linecord is equipped with a 30 ampere grounding plug ("Hubbel type 3331"). The AC voltage for which the unit has been set is indicated on a tag attached to the linecord. The input can be changed for any of the other specified input voltages as follows:

1. Remove the skid-rails and panel from the underside of the unit.

2. Locate the primary terminals of the main power transformer, T201, on the underside of the chassis near the front of the unit. These are 8 stud terminals, numbered 1 to 8 and equipped with 3/8-in. brass hex nuts.

3. Connect the movable jumper links on T201 so they are connected as follows for the input voltage indicated:

   104 volts: between 4 & 7; and between 5 & 6
   115 volts: between 2 & 5; and between 3 & 4
   208 volts: between 6 & 7 only.
   230 volts: between 2 & 3 only.

4. Be sure to connect the Power Supply only to the voltage for which the input has been set. Change the tag to show the correct voltage after it is changed.

5. If it is necessary to install a different linecord plug, be sure to connect the green wire in the linecord to ground.

AUTOTRANSFORMER TAPS. - The primary windings of the transformer are operated as autotransformers to provide 115 volts for the fan motors, input relay, and for the primary of the auxiliary power transformer T202. This automatically provides 115 volts for their operation regardless of the input voltage at which the Power Supply is operated.

COOLING. - The power transistor assemblies and rectifier assembly are maintained within proper operating temperatures by built in fan units which circulate air laterally through the unit. Be sure all panel openings are clear to permit proper circulation of air.

GROUNDING. - The DC output is isolated from the AC power line and from any direct connection to chassis or ground. The Positive side of the output is connected to chassis through a 0.5 μf 600 volt capacitor in series with a 10 ohm resistor. Either side of the DC may be grounded. A DC grounding lead, connected internally to the chassis and equipped with a spade lug is provided near the DC terminals for this purpose. To ground one side of the DC, remove the spade lug from under the Phillips-head mounting screw for the DC terminal board and fasten it under the hex-nut located at the end of either one of the DC busbars.

The chassis is connected to the third, grounding wire (Green) in the line-cord, and this wire is connected to the grounding pin of the plug on the linecord. Connected to a properly wired receptacle the chassis will be grounded.

DC LOAD TERMINALS. - The load should be connected only to the two load terminals provided for that purpose. The connecting leads should be carefully constructed, keeping in mind the voltage drops that can develop at the very high current with wires of insufficient size or poor terminal connections. (See Remote Error Sensing, Page 9).

On units equipped with barrier type output terminals the wires should be connected to cable lugs that fit #12 screws, or the conductors may be wrapped conventionally. On units equipped with the bronze compression-type terminals, these will accept wire sizes from #4 to #1, without wrapping.

STANDARD OPERATION. - The Supply is shipped with six removable jumper links in place between terminals (1)-(2), (3)-(4), (5)-(6), (7)-(8), (10)-(11), and (12)-(13), on the 14-terminal control terminal strip on the back of the unit. These links must all be in place for standard operation.

NOTE: The terminal screws and links should be tight to insure proper operation. A loose wire connection or jumper link can cause the unit to function improperly. Be sure to put any links that have been removed back in place when changing from one mode of operation to another.

TURN ON. - The Supply may be turned on and off with the front panel Voltage and Maximum Current controls turned to any settings without any precaution. There is no warm-up period and regulated voltage appears instantly after turn-on. Whenever the input relay releases, it connects a low resistance across the input filter capacitors to prevent overshoot following turn-off or power failure.

SETTING OUTPUT VOLTAGE AND MAXIMUM CURRENT. - The output voltage is adjustable over its range by means of the Voltage Adjust control on the front panel. (Note: Control shaft friction is built in to protect Potentiometer.)
The output current will be determined by the resistance of the load and the output voltage setting, except that the maximum current is adjustable and can be set by means of the Maximum Current Adjust control on the front panel. It may be set to limit at any value regardless of the resistance of the load, in the range from 0.5% to 100% of the rated maximum output current of the unit. The current limits sharply at this setting and will be maintained constant, within 0.5% (or 50 milliamperes, whichever is greater) for any load change between this setting and short-circuit.

The output will have the characteristic of either a constant voltage or a constant current source, depending on: a) the voltage setting; b) the maximum current setting; and c) the value of load resistance. A sharp crossover point exists where the output characteristic changes between constant voltage and constant current for a change in load. For any given setting of the Voltage Adjust and Maximum Current Adjust controls, this crossover occurs at a point where the load resistance is equal to the Voltage setting divided by the Maximum Current setting.

At load currents below the Maximum Current setting, the Supply will have a constant voltage output, and current will vary with load changes. A change in load that would tend to increase current (decreasing resistance) above the Maximum Current setting will result in the current being held limited at that value, and voltage will decrease below its set value with the decrease in load resistance.

Procedure. -

1. When no specific current limiting is required below the rated maximum current of the unit, the Maximum Current Adjust control may be set to its maximum, fully clockwise position. This setting will allow the output to be operated at any current in the range of the Supply without limiting taking place. It will however still afford sharp limiting just above rated maximum output, for overload protection.

2. It should be noted that when setting output voltage with a load connected, a combination of Maximum Current setting and load resistance can be such that it can have the effect of limiting the output voltage to some value below the rated maximum voltage of the unit. Under such conditions it will be found that the voltage can not be raised higher than a value equal to the Maximum Current setting times the load resistance. Where this occurs it may be necessary to disconnect the load while the output voltage is being set.

3. To set the Maximum Current. -

a. Set the output voltage, with the load disconnected.

b. Set the Maximum Current Adjust Control up to maximum (clockwise) position; connect a load to draw the desired maximum operating current; turn the Maximum Current Adjust control down counterclockwise until a perceptible downward movement is noted on the panel meters, indicating that limiting is taking place. Raise the control slightly above this setting, enough to be just above the point of limiting.

c. An alternate method for setting the Maximum Current is: first set the voltage (as in a. above), then set the Maximum Current Adjust down to minimum (fully counterclockwise) position and connect a short-circuit across the output terminals; turn the Maximum Current Adjust control up until a current reading approximately 5% higher than the maximum intended operating current is obtained. Remove the short-circuit.

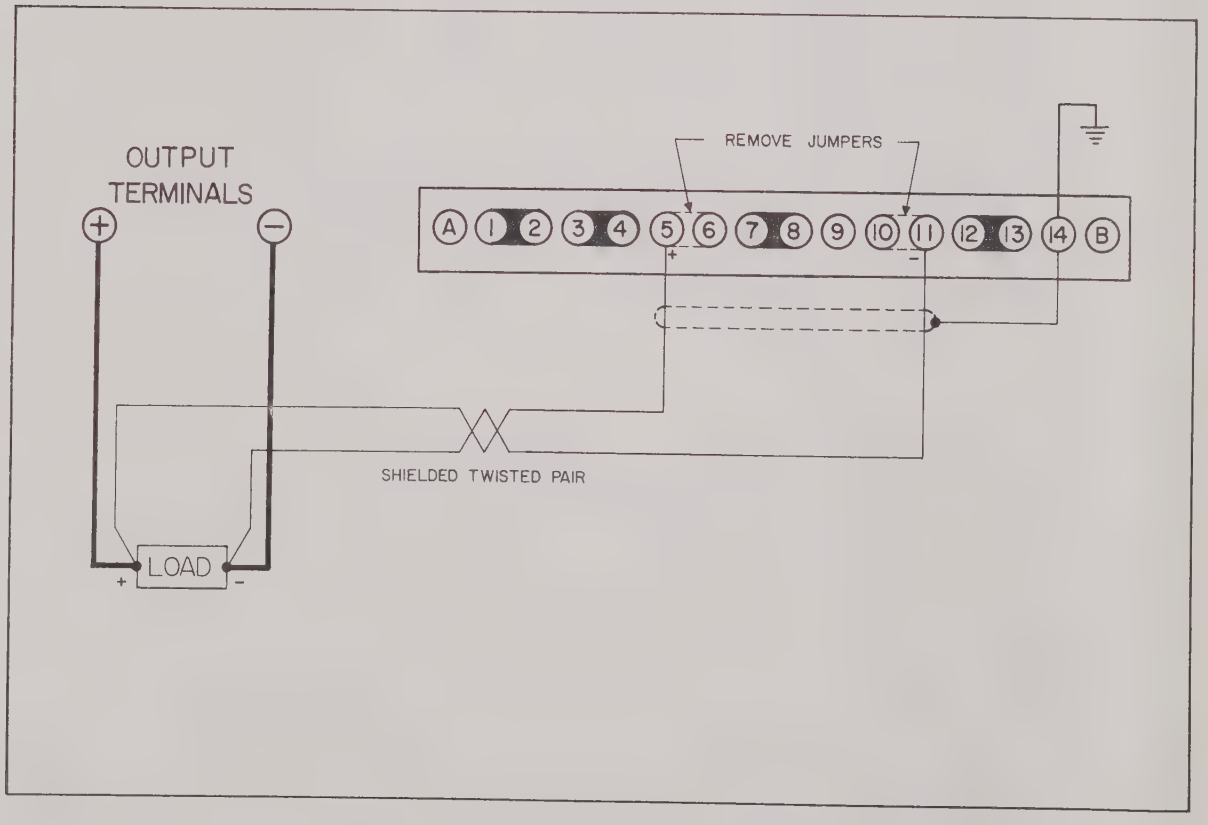


Fig. 1 CONNECTIONS FOR REMOTE ERROR SENSING

REMOTE ERROR SENSING. - The Error Sensing terminals are the input terminals to the Supply's regulating system for sensing changes or errors in the output voltage being regulated. Normally, the Error Sensing is connected to sense the output voltage directly at the output terminals on the back of the Power Supply. Connected in this manner optimum specified regulation will appear at these terminals, while the voltage at the load will be reduced by voltage drops due to resistance in the wires between the output terminals and the load.

The Error Sensing input can be connected to sense the voltage directly at the load, thereby maintaining optimum regulation at the load instead of at the Supply's terminals. Up to 0.5 volts in each load connecting lead can be compensated for by using Remote Error Sensing.

Procedure. - (See Fig. 1)

1. Remove the two Remote Error Sensing jumper links connected between terminals (5)-(6) and between (10)-(11), on the back of the unit. These links provide error sensing of the voltage at the Supply's terminals and must be in place when Remote Error Sensing is <u>not</u> being used.

2. Using a twisted pair wire, that will be separate from the main load connecting wires, connect the Error Sensing terminals (5) and (11) to the DC terminals at the load. Be sure to maintain polarity, i.e., connect the Positive Error Sensing (5) to the Positive side of the load, and Negative Error Sensing (11) to the negative side of the load. The Remote Sensing wires are used to transmit voltage only and do not carry load current.

NOTE: The unit should never be allowed to operate with an open circuit existing between either Remote Error Sensing terminal and its respective output terminal - that is without either the jumper links or the Remote Error Sensing wires properly in place. An open connection will cause the output voltage to rise above the rated maximum for the unit and activate the overvoltage side of the input circuit breaker, shutting off input power.

OVERTEMPERATURE PROTECTION. - The unit will shut off automatically in the event of an internal overtemperature condition, which can develop as the result of a malfunction or failure in the air circulating system. Thermostatic switches are located in position to sense the temperature in the immediate vicinity of both the main Rectifier Assembly and the Pass Transistor Assemblies. Upon activation, a thermostat will trip the main Power Switch/Breaker, by means of the low current coil, thereby shutting off Power in the unit. After the internal temperature returns to within normal range and the thermostat resets, it is necessary to manually turn the unit On to restore DC output.

OVERLOAD PROTECTION. - The main Power Switch/Breaker contains two separate activating coils, either one of which is capable of tripping the Switch/Breaker and turning Power off. A current overload coil is connected in series with the main transformer primaries to sense input power overloads. The circuit is designed so that the overload coil is subject to approximately the same values of normal and overload input currents regardless of which input voltage the primaries are connected for. The other coil is a low current overload coil which is designed to be operated by an overvoltage at the preregulated input power to the Series Pass Elements. It is also activated by operation of any of the overtemperature sensing thermostat switches.

CONTROL FUSE. - The primary of the power transformer that provides the various internal DC Supply voltages, other than the main DC power, is protected by a fuse which is accessible on the front panel.

2-2 SPECIAL OPERATING PROCEDURES

CONSTANT CURRENT OPERATION. - When operating in the voltage regulated mode, the output current of the Supply varies with changes in load to maintain a constant voltage across the load. For constant current operation the voltage across the load must change with changes in load resistance. The total range of load variation over which a given value of constant current can be maintained is governed by the total output voltage range of the Power Supply. With regard to constant current operation, this voltage range is referred to as the "Compliance Voltage".

The KS Power Supply can be operated in the constant current mode simply by setting the Maximum Current Adjust control for the desired value of current, and setting the Voltage Adjust control for the upper limit of compliance voltage. The Supply will maintain a constant value of current through a changing load as long as the load resistance remains within the limit imposed by the compliance voltage range.

For Example: assume that with a Model KS 8-100 (0-8 volts, 0-100 amperes), it is desired to operate 50 amperes constant current, with maximum compliance range, through a load subject to variation but having a starting value of 0.1 ohms. The Voltage Adjust control would be set to rated maximum (8 volts), and the Maximum Current Adjust control set for 50 amperes. At 8 volts, 0.1 ohms would ordinarily draw 80 amperes. However the Maximum Current setting limits the current at 50 amperes, while the voltage assumes the value of 5 volts. If the load were to vary in the direction of decreasing resistance, instead of current increasing as it would in the regulated voltage mode, it remains at 50 amperes. The current will remain at 50 amperes all the way to zero ohms load, or short-circuit. If the load varies in a direction of increasing resistance, instead of the voltage being held at 5 volts, as it would in regulated voltage mode - which would result in current decreasing - the voltage is free to increase up to the compliance limit. The current will remain at 50 amperes, while the voltage increases with increasing load resistance, until the voltage reaches the maximum or limit of compliance voltage (8 volts in this case). Any further increase in resistance past the point where the constant current value times load resistance is equal to the maximum voltage setting, will result in the current decreasing from 50 amperes while voltage remains constant. At this point, (8 volts) the output will automatically cross over into the regulated voltage mode from the constant current mode.

It is not always necessary to set the output voltage to the maximum output of the Supply except where the main requirement is for constant current and maximum range of compliance voltage is desired. The voltage may be set at some value below maximum output so the Supply will automatically go into constant voltage at this lower voltage.

It should be remembered that in any form of constant current operation the range of load variation is subject to the range of voltage compliance available, at the current desired.

In constant current operation as described above, using the Maximum Current Adjust function, the Power Supply utilizes an internal current regulating system which employs an internal current sensing resistor in series with the output to detect current changes. Current regulation in this mode of operation is 0.5% (or 50 milliamperes, whichever is greater) for a change in load corresponding to a change from maximum rated voltage to zero volts. Constant current operation may also be obtained by utilizing the voltage regulating capabilities of the Supply in conjunction with an external load current sensing resistor; see "Programming Constant Current With External Sensing", page 19.

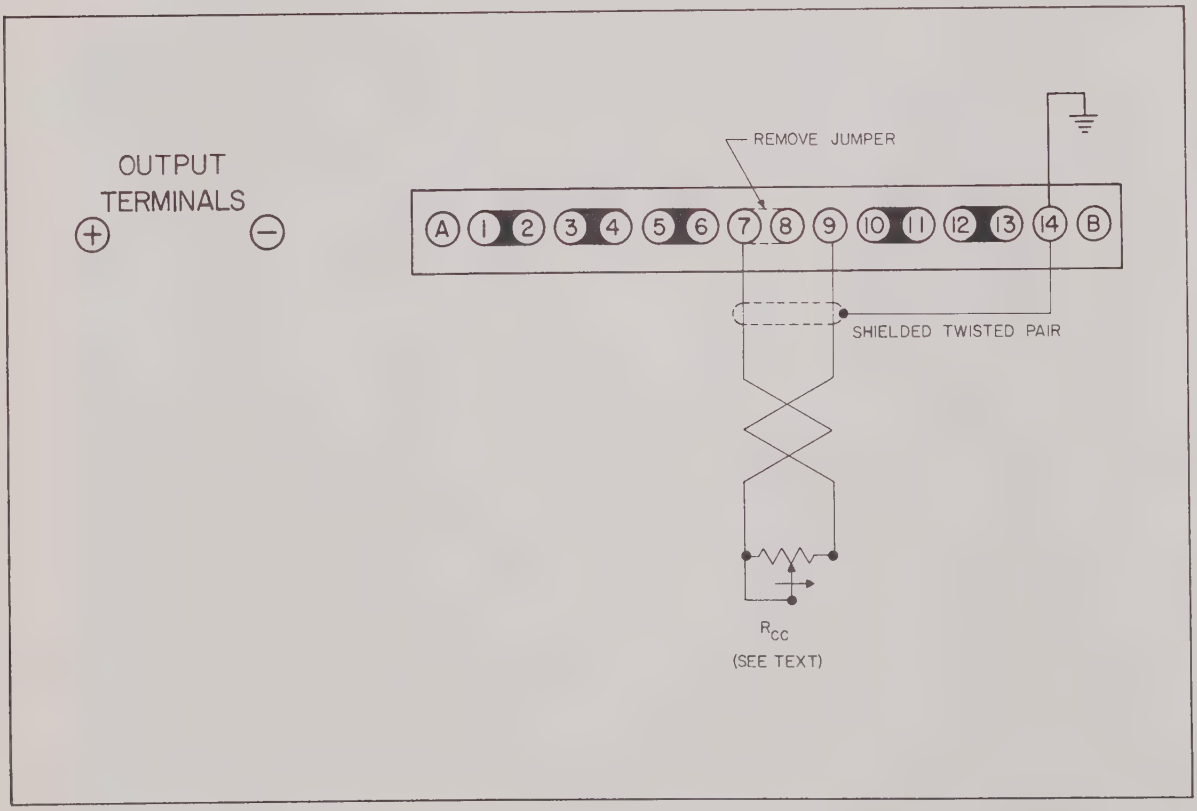


Fig. 2 CONNECTIONS FOR PROGRAMMING MAXIMUM CURRENT BY EXTERNAL RESISTANCE

PROGRAMMING CONSTANT CURRENT WITH INTERNAL SENSING. - (External Programming of Maximum Current Adjust) The adjustable, constant Maximum Current function normally controlled by the setting of the Maximum Current Adjust control on the front panel, may be programmed either by an external resistance or by voltage.

Programming Maximum Current by Resistance. -

In this mode of operation an external resistance is connected to the unit to function as a Maximum Current Adjust control in place of the front panel control. The external control may either be fixed, stepped, or continuously variable, and may be located remotely from the Power Supply. If fixed values of resistance are to be switched, for stepping the current, the switching device should have shorting contacts (make before break), so the circuit does not open during transfer.

Caution: The Maximum Current Adjust control on the front panel is calibrated internally so that at its maximum setting, the maximum output current will be limited at a maximum value equal to 0.5 ampere more than the rated maximum current for the particular Model. When an external resistance is used it must similarly be calibrated at maximum, and the front panel control recalibrated when going back to normal operation. (See Calibration Adjustments, page 25.)

Procedure. - (See Fig. 2)

1. Using shielded, twisted-pair wire, connect the external resistance to terminals (7)-(9); connect the shield to ground (14). Remove the jumper connected between terminals (7)-(8); this disconnects the front panel Maximum Current Adjust control from the circuit.

2. For a continuously variable control, the external resistance should have a range of 0-75 ohms. This will have to be calibrated at maximum setting before operation.

3. For step function control, fixed resistance values can be approximated, subject to exact calibration of the current, by proportioning 0 to 75 ohms for the fraction of maximum rated current to be programmed. For example: to obtain a maximum current setting at 50% of rated maximum, a fixed resistor with a value of 37 ohms (50% of 75 ohms) should be used, subject to calibration of the current for the exact value.

4. Calibrate the external control in accordance with the Procedure for Calibrating Maximum Current Adjust Control (page 25).

Programming Maximum Current by Voltage. -

In this mode the Maximum Current Adjust function is controlled, or programmed, by an external voltage. A variation in the programming voltage will vary the effective Maximum Current setting. The programming voltage may have any value. It is coupled to the unit through an externally connected resistor (R_{RC}). This resistor is calculated by Ohm's Law to provide approximately 8 milliamperes at the maximum value of programming voltage. The actual resistor used should be adjustable, and should have a slightly higher (10%) value than calculated. It must be adjusted, at the maximum programming voltage, to calibrate for Maximum Current (with the maximum programming voltage) to prevent the maximum rated current from being exceeded.

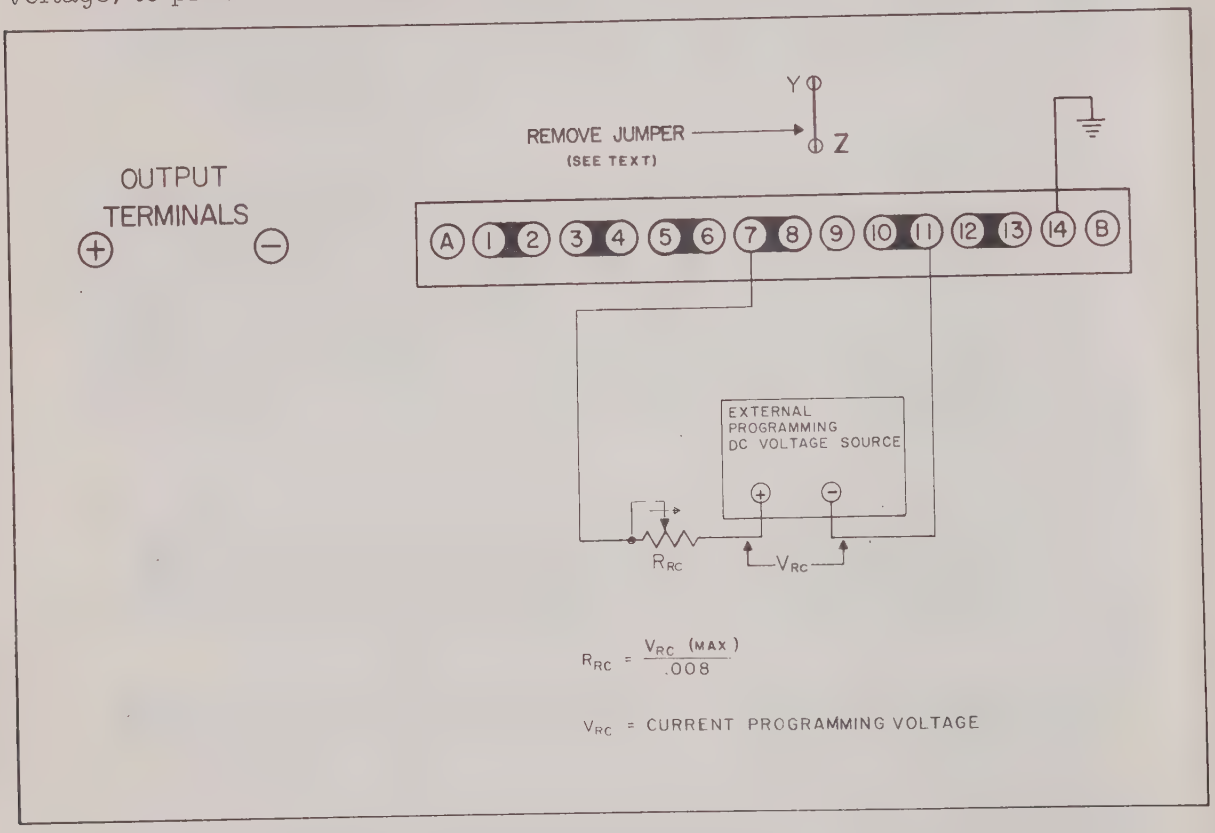


Fig. 3 CONNECTIONS FOR PROGRAMMING CURRENT BY VOLTAGE.

Procedure. - (See Fig. 3)

1. In order to calibrate the external coupling resistor (R_{RC}), the Power Supply must be pre-set with a load for maximum rated output current, before setting up the programming by voltage. With the front panel Voltage and Current controls both set to maximum, connect an adjustable load to the unit and set it to draw exactly the maximum rated current for the Model. Leave the front panel controls and the load at that setting and turn the unit Off.

2. Remove the steel panel covering the circuit board on the back of the unit. On the circuit board, locate two turret terminals, labelled (Y) and (Z) and fitted with a soldered bus-bar jumper. (See Fig. 8 for location of terminals Y and Z). Unsolder and remove the bus-bar jumper.

3. The cover panel may be reinstalled. Connect the negative side of the programming voltage to terminal (11) on the back of the unit. Connect one end of the external coupling resistor, (R_{rc}), to the positive side of the programming voltage, and the other end to terminal (7).

4. With the programming voltage set to its maximum value, calibrate the maximum current as follows:
   a. Set the external resistor R_{rc} to its highest value.
   b. With the front panel controls both at maximum and the load connected and set exactly for rated maximum current, turn the programming source and the Power Supply On. With R_{rc} at the higher resistance setting, output current should be some value below rated maximum. Adjust R_{rc} in the direction of decreasing resistance, increasing output current until exactly rated maximum is obtained.

5. Varying the programming voltage down from its maximum value should vary the effective Maximum Current setting proportionately.

PROGRAMMING OUTPUT VOLTAGE BY EXTERNAL RESISTANCE. - The output voltage may be programmed, or controlled, over its entire range by means of an externally connected resistance. The external control may be continuously adjustable or stepped, and may be remotely located. When connected it will function in place of the front panel Voltage Adjust control.

The external resistance will control the output voltage at a ratio of approximately 1 volt per 100 ohms. This means that if a 500 ohm resistor is connected to the control terminals, 5 volts will be obtained at the output; if a 0-800 ohm adjustable resistor is connected, it will be possible to control or vary the output over the range 0 to 8 volts. The exact control ratio is adjustable a small amount around the 100 ohms-per-volt value in order to permit adjustment for component tolerances. This is done by means of the internal Voltage Control Calibrate resistor. The control ratio will remain essentially constant over the entire output range of the unit. It is usually adjusted, either for internal or external control at maximum rated output voltage. (See Calibration Adjustments, page 26).

Procedure. - (See Fig. 4)

1. Remove the jumper link connected between terminals (3)-(4) on the back of the unit. This disconnects the internal Voltage Adjust control from the circuit.

2. Using shielded, twisted-pair wire, connect the external resistance to terminals (3)-(5). Connect the shield to the chassis, terminal (14).

If fixed values of resistance are to be switched for stepping the voltage, the switching device should have shorting contacts (make before break) so the circuit does not open during transfer.

Programming large excursions of voltage by switching contacts or other rapid switching means requires the use of high voltage resistors for the lower voltages programmed. This is necessary to absorb the higher voltage charge stored in the output capacitors. Similarly, manually operated or servo driven potentiometers of low current capacity must be restricted in their speed of rotation by friction or other means to prevent potentiometer burn-out. These precautions are particularly significant when the supply is lightly loaded.

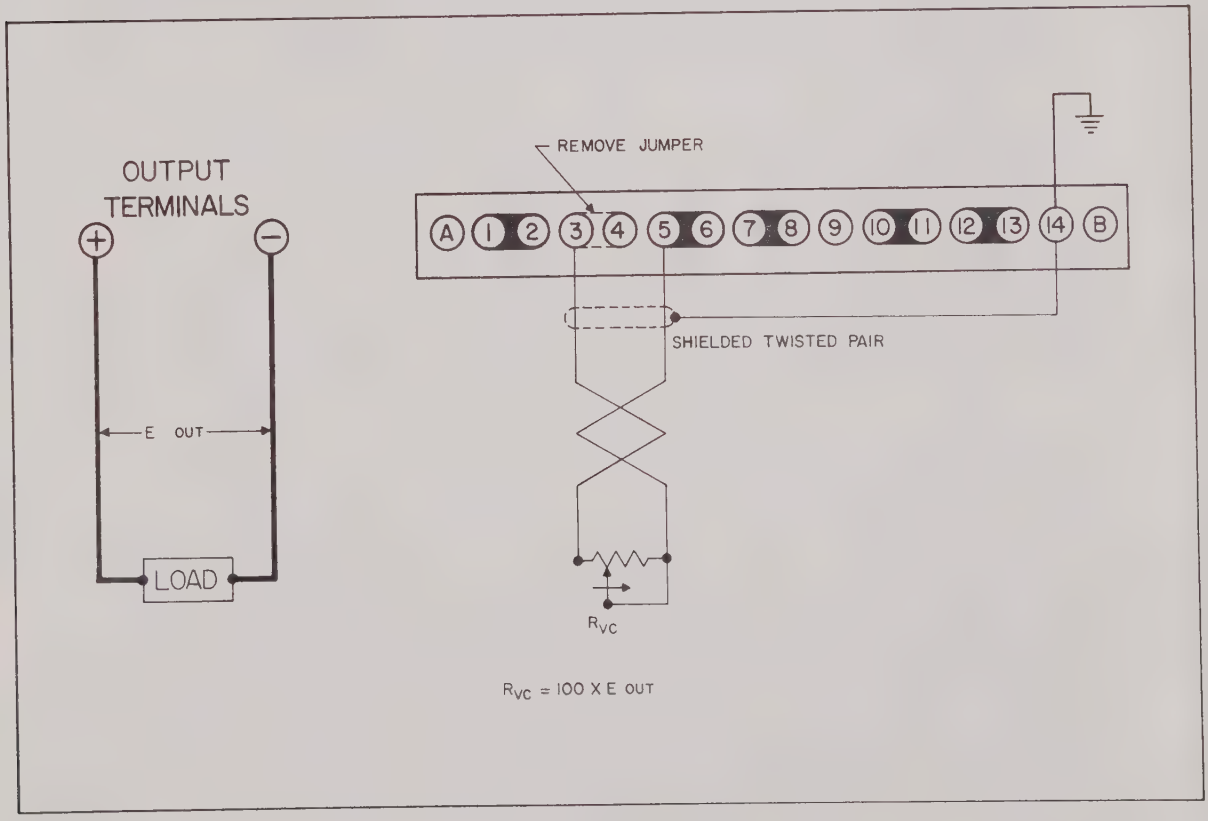


Fig. 4 CONNECTIONS FOR VOLTAGE PROGRAMMING BY EXTERNAL RESISTANCE

PROGRAMMING OUTPUT VOLTAGE BY EXTERNAL VOLTAGE. - The output voltage of the Model KS can be controlled, for the purpose of special programming applications, by another separate and external voltage source. The output voltage of the programmed Supply will be made to follow, that is, to maintain a value that will be in constant proportion to the voltage of the programming source.

The proportion between the two voltages will be constant, but adjustable. It is determined by the proportion established between the resistance of an added external coupling resistor (R_r) and the resistance at which the output voltage control potentiometer (R_{VC}) is set. The proportion may be set at unity (1:1) in which case the output voltage will remain equal to the programming voltage, or it may be set for any other ratio, within the voltage capabilities of the unit.

This mode of programming may be used in conjunction with an external Voltage Control resistance (see Programming Output Voltage by External Resistance) to provide programming control of both the magnitude and the ratio of the voltages.

It is a requirement that the positive side of the programming voltage source be connected to the negative side of the programmed voltage. Also, the programming source must be capable of providing at least 10 milliamperes to supply the internal reference bridge of the programmed Power Supply.

Procedure. -

1. The proportion maintained between the output voltage and the programming voltage is expressed very closely by the following:

$$\frac{V_o}{V_r} = \frac{R_{VC}}{R_r}$$

where: V_o = Output Voltage to be programmed
V_r = Programming voltage.
R_{VC} = Voltage Control resistance (internal or external)
R_r = External coupling resistor.

2.a. The values of V_o and V_r are usually given by the requirements of the particular application.

b. The value of R_r is determined by Ohm's Law to obtain 10 ma for the internal reference of the programmed Supply, using the programming voltage at its maximum value:

$$R_r = \frac{V_r\,(\text{max.})}{.01}$$

c. R_{VC} is equal to V_O x 100.

3. Set-up Procedure: (See Fig. 5)

a. Connect the positive side of the programming voltage (V_r) to terminal (11). Using shielded wire, connect the external coupling resistor (R_r) between the negative side of V_r and terminal (3) on the programmed Supply; connect the shield to ground (14).

b. Remove the jumper link connected between terminals (1)-(2) on the Programmed Supply.

c. On the programmed Supply set the voltage control (either internal or external) approximately for the maximum value of voltage to be programmed.

d. Turn on the programmed Supply and the programming voltage source. With the programming voltage set to its maximum value, adjust the voltage control on the programmed Power Supply to establish the desired ratio. The programmed output voltage should track variations in the programmed voltage at the proportion established.

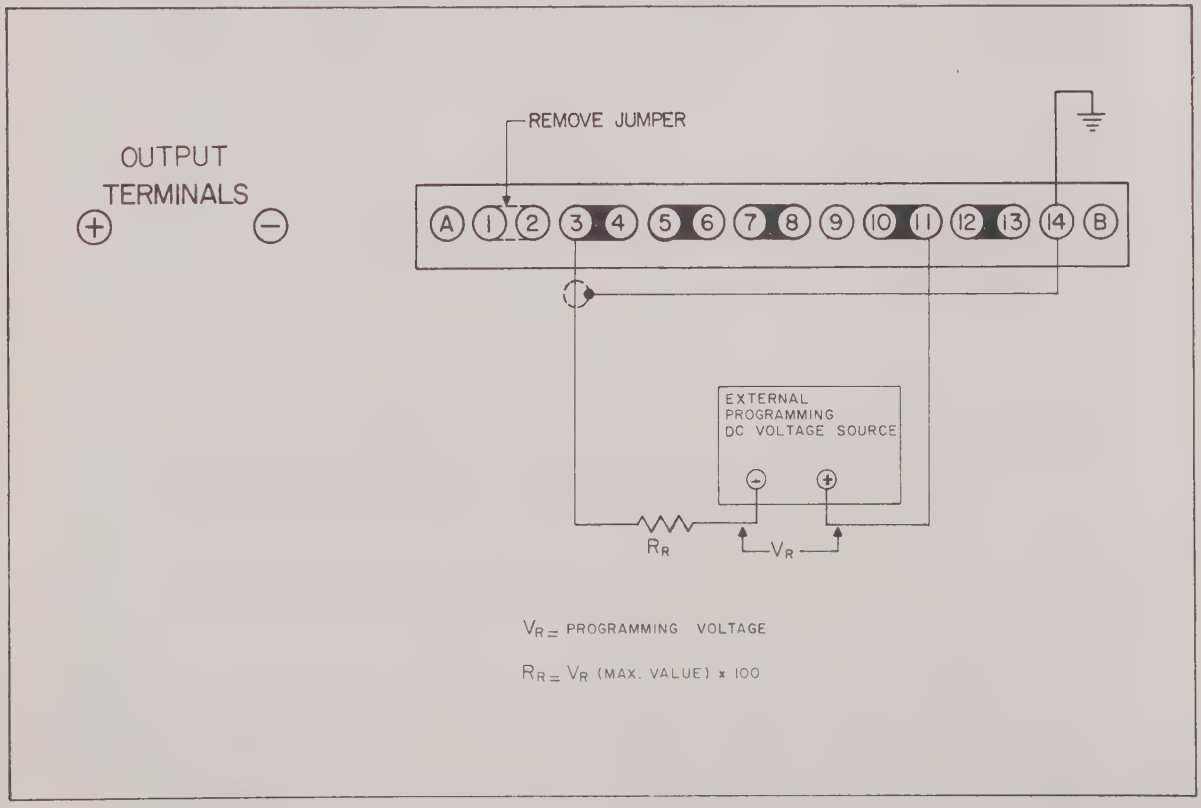


Fig. 5 CONNECTIONS FOR PROGRAMMING VOLTAGE BY EXTERNAL VOLTAGE

PROGRAMMING CONSTANT CURRENT WITH EXTERNAL SENSING. - The output of the unit can be converted to provide, with external current sensing, constant current through a varying load. Current regulation on the order of 0.1% can be achieved in this mode of constant current operation depending on the choice of external sensing and control resistors.

A current sensing resistor, R_S, is connected to the output in series with the load on the negative side. (See Fig. 6) A voltage, V_S, directly proportional to output current will be developed across R_S.

A current control resistor, R_C, is connected between the load end of R_S and the programming input terminal, (3). A constant current of 10 milliamperes, derived from the Power Supply's internal fixed reference voltage flows through control resistor R_C. This current is constant and determined entirely by the internal reference circuit, independent of the value of R_C and of output current. The voltage (V_C) across R_C will be equal to the resistance of R_C times 10 ma, and will be constant at that value.

The regulating system in the Supply will act to control current to the load so as to maintain the voltage V_S, across the sensing resistor equal to the constant voltage V_C, across the control resistor. By maintaining the voltage across R_S at a constant value, it maintains output current constant.

The actual value of constant output current is determined by the value of resistor R_S and the sensing voltage that must be maintained across it. The sensing voltage will be the same as the voltage established across R_C by the fixed 10 ma current from the internal reference. A nominal 1 volt is recommended as a practical value, requiring that the resistance of R_C be 100 ohms. By using a variable resistor for R_C, the voltage across it can be adjusted, providing a convenient means of varying the output current. This provides a variable range of current for any one value of sensing resistor, and allows the use of more readily available standard values of resistors.

NOTE: R_C determines the sensing voltage that will be maintained across R_S. At 1 volt, current regulation is 0.1% or better. Varying this voltage varies the output current. However as this voltage is decreased, current regulation is degraded gradually and operation at sensing voltages below 0.2 volt is not recommended. A nominal 1 volt is chosen to be a practical value. Higher voltages do not appreciably improve regulation, while they do increase the dissipation requirements of the sensing resistor, and take more compliance voltage away from being available to the load.

Procedure: (See Fig. 6)

1. Determine the value of R_S on the basis of 1 volt divided by the maximum value of constant current that will be required. The resistor selected should have a power rating at least ten-times its actual dissipation requirement, and should have a low temperature coefficient.

If the exact resistance calculated for R_S is an impractical value, use the nearest lower value available and adjust the current to the exact value required with the current control resistor, R_C.

2. Connect R_S in series, between the negative DC output and the load. Connect the current control resistor (100 ohm variable) between the load end of R_S and the terminal (3) on the rear. Remove the jumpers connected between terminals (3) and (4).

3. To prevent the internal Maximum Current function from interfering with this external sensing mode, the Maximum Current Adjust control on the front panel should be turned to its maximum, fully clockwise position. This circuit may be more positively inactivated by disconnecting the jumper link on terminals (7)-(8) at the rear.

4. With the Supply turned on and loaded, adjust the current control resistor to obtain the required value of output current. R_C may require resetting until the resistors warm up to equilibrium.

Caution: When using the external sensing mode of constant current operation it is important not to allow the load to achieve a value that will, at the current being drawn, attempt to develop a voltage across the output exceeding the rated maximum output voltage of the Power Supply. The voltage across the output will be equal to the product of the total resistance across the output (load resistance plus sensing resistor) times output current. In this mode the output of the Supply does not crossover into constant voltage at maximum output. Consequently if the output voltage is permitted to exceed rated maximum it can trigger the Circuit Breaker by overvoltage, shutting off the Supply.

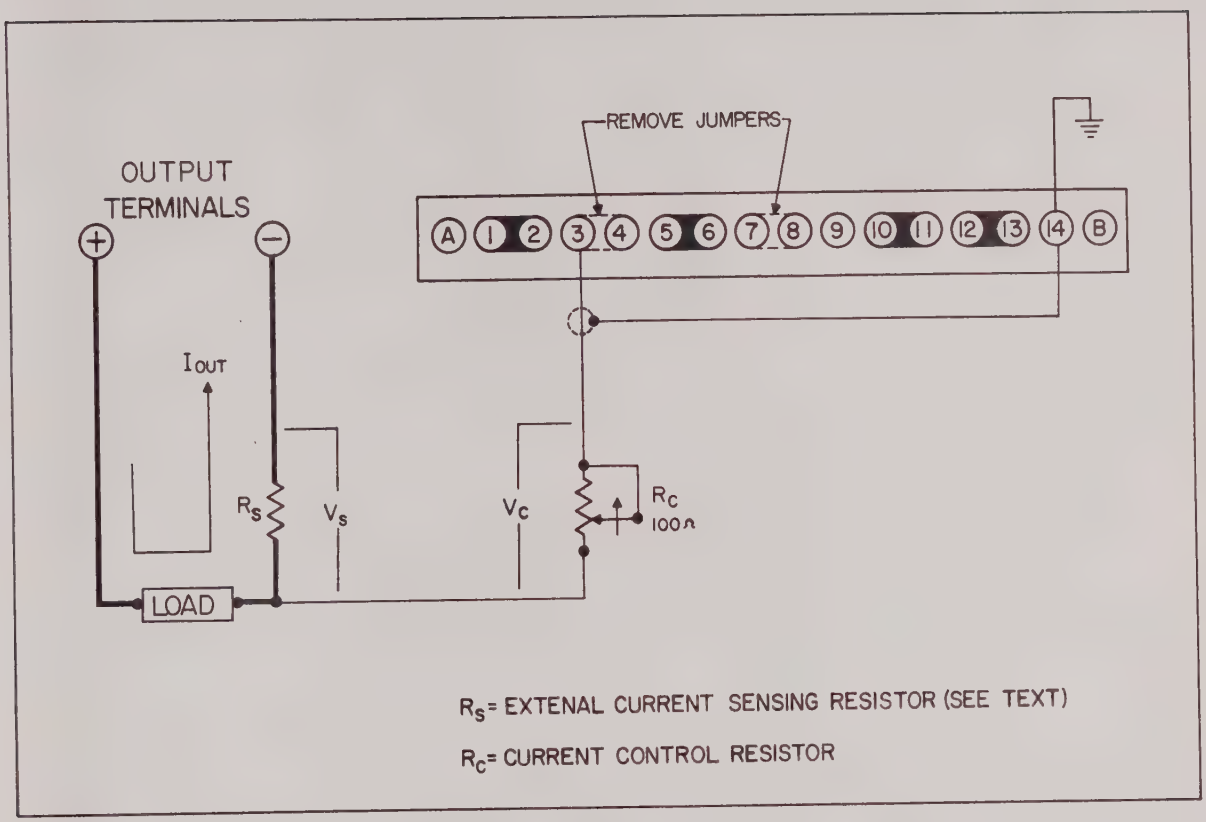


Fig. 6 CONNECTIONS FOR CONSTANT CURRENT OPERATION WITH EXTERNAL SENSING RESISTOR

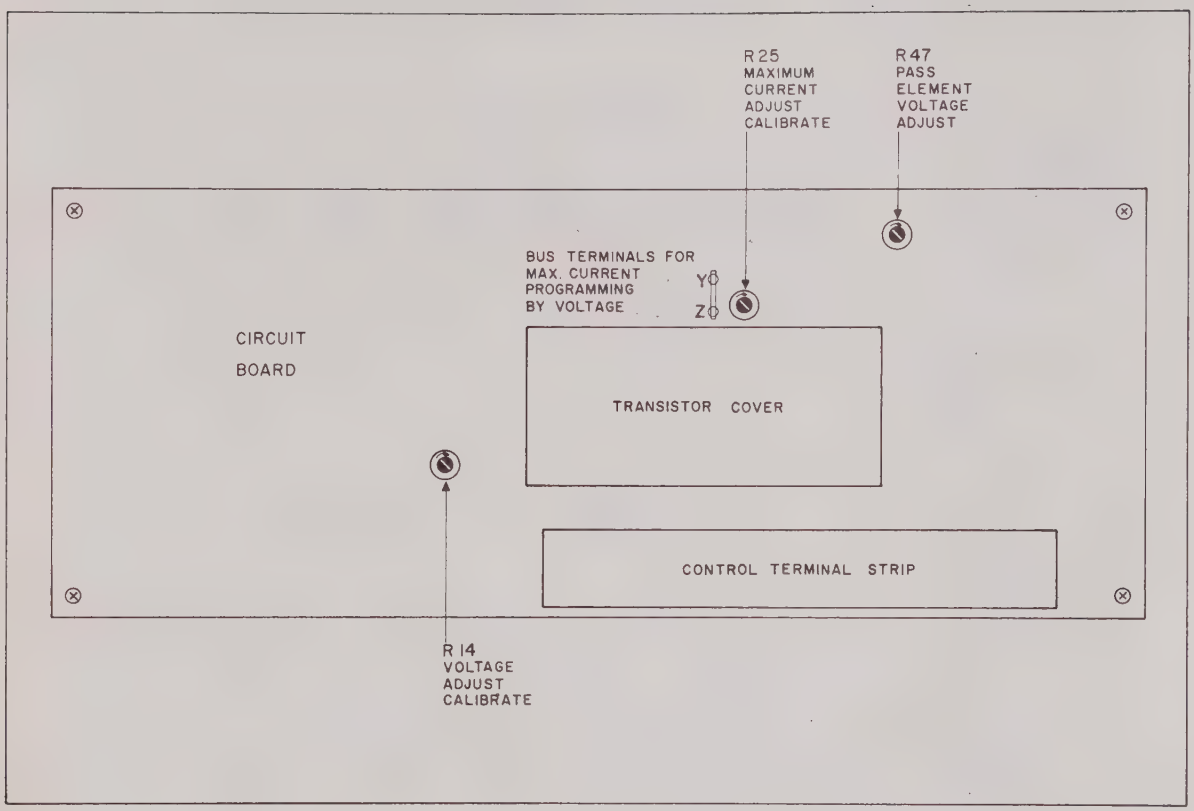


Fig. 8 CALIBRATION ADJUSTMENTS ON PRINTED CIRCUIT BOARD

2-3 INTERNAL CALIBRATION PROCEDURES.

There are four internal circuit calibration adjustments in the Supply. Their location and function are described below, followed by instructions for checking and adjusting them should this be required. These are all pre-set at the factory and none should require adjustment except following the replacement of a circuit related component, or when it may be required in conjunction with one of the special programming applications.

With the exception of the Ammeter Calibrate adjustment, all of the adjustment controls are located on the Printed Circuit Board. They are miniature one-turn potentiometer controls similar in size and appearance to the transistors (TO-9 case) on the Circuit Board. They are adjusted by means of a small screwdriver. Refer to Fig. 8 for their location and identification on the Circuit Board. The Circuit Board, containing the calibration controls is accessible by removing the panel on the back of the Power Supply.

1. Ammeter Calibrate. - This is a one-turn potentiometer control with a locking screwdriver type shaft, located on the back of the front panel. This adjustment calibrates the front panel ammeter, at full-scale, to the internal current sensing circuit. It is accessible by removing the top panel of the Power Supply.

   Adjustment Procedure. -

   a. Turn the Maximum Current Adjust control (front panel) to maximum, fully clockwise position. Connect a load and an external calibrated Ammeter to the output of the Supply, to draw exactly the rated maximum current of the unit; adjust the internal Ammeter Calibrate to obtain the same reading on the front panel ammeter.
   b. The Ammeter Calibrate control should be locked by tightening the locking collar on its shaft.

2. Pass Element Voltage Adjust. - This is a one-turn potentiometer (R47) located on the Circuit Board. Its purpose is to adjust the preregulated voltage output of the main rectifier with respect to the final regulated output voltage of the Power Supply. The preregulated voltage varies automatically with the regulated output voltage and remains always a constant amount higher than the output. The difference between the two is set by this adjustment and constitutes the voltage across the series Pass Elements.

   Adjustment Procedure. - This adjustment is made while measuring the voltage across the emitter and collector terminals on the series Pass Element transistors. The emitter of each Pass transistor is brought out to a test terminal on the top of each Pass transistor heat-sink assembly to facilitate this measurement. Since the Pass transistor assemblies are all connected in parallel, the adjustment may be made while measur-

ing at any one transistor, and a reading taken at all the other assemblies afterward to make certain they all read the same. A different reading at one would indicate trouble in that particular Pass assembly.

a. Remove the top panel of the unit, and the back panel for access to the Circuit Board. Locate the Pass Element Voltage Adjust (R47, See Fig. 8).

b. Connect the positive side of a DC voltmeter to the emitter test point on one of the Pass transistor assemblies; connect the negative meter lead to the heat-sink frame of the same assembly - this is common to the collector.

   CAUTION. Be careful not to short out the emitter test terminal to the heat-sink frame.

c. Check the emitter-collector voltage at maximum rated output voltage, and no-load. If it is more than *4 volts, reduce it to *4 volts by turning down R47. *5 volts for KS 36-30; 6 volts for KS 60-20.

d. Connect a load to the unit and set it to draw exactly the rated maximum output current of the unit. Readjust R47, at full-load, to obtain 2.5 volts across the emitter-collector. This is the correct final setting.

3. Voltage Adjust Calibrate. - This adjusts the constant control ratio between the resistance of the Voltage Adjust control, either internal or external, and the output voltage. This control ratio is intended to have a nominal value of 100 ohms per volt, but is made adjustable around that value to allow exact calibration of the output voltage to the control resistance.

   Adjustment Procedure. -

   a. Remove the back panel for access to the adjustment which is located on the Circuit Board. Locate the Voltage Adjust Calibrate (R14, see Fig. 8).

   b. To calibrate for the front panel Voltage Adjust control, turn both front panel controls, Voltage and Maximum Current up to their maximum (clockwise) position. With no load connected, adjust the Voltage Adjust Calibrate to obtain an output voltage 5% higher than the rated maximum for the particular Model; e.g., 8.4 v for KS 8-100; 18.9 v for KS 18-50; etc.

   c. To calibrate for an external control, first set the external control to its maximum position, and adjust the Voltage Adjust Calibrate to obtain an output voltage equal to the exact maximum resistance of the external control, divided by 100. This value should not exceed a voltage 5% higher than the rated maximum output voltage of the unit.

4. Maximum Current Adjust Calibrate. - This sets the upper end of the range of the Maximum Current Adjust control on the front panel (or an external control if one is used). It is adjusted so that the maximum Current Adjust control is set to its maximum, will not exceed 0.5 ampere more than the rated maximum current of the particular Model.

   Adjustment Procedure. -

   a. Remove the back panel for access to the adjustment which is located on the Circuit Board. Locate the Maximum Current Adjust Calibrate, (R25, See Fig. 8).

   b. Connect a variable load to the output, through an accurate external ammeter.

   c. Set the output voltage to maximum rated output voltage; turn the Maximum Current Adjust control to its maximum (clockwise) position; turn the Maximum Current Adjust Calibrate to maximum clockwise position.

   d. Starting from no-load, increase load current to obtain output current 1 ampere higher than rated maximum for the Model. Adjust the Maximum Current Calibrate to obtain an output current 0.5 ampere higher than rated maximum.

kepco inc. ® REPLACEMENT PARTS LIST

POWER SUPPLY MODEL KS-8-100M Code 1-1863

SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
B201	1	Fan, Venturi	Rotron	149-0013
B202	1	(Same as B201)		
B203	1	(Same as B201, 202)		
C101	1	Capacitor,Fixed,Mylar 2 μf, 200 V	Hopkins Eng. 2P2MK	117-0129
C201	1	Capacitor, Paper Can 30 μf, 275 V	General Elec. 49 F 4320	117-0351
C202-207	6	Capacitor,Electrol., Can 68.5 K μf, 15 V	Sangamo DCM	117-0305
C208	1	Capacitor,Paper Can 0.5 μf, 600 V	Pyramid Elec. MPDM 6-P5	117-0180
CB101	1	Switch,Circuit Breaker	Heinemann XAM46	127-0161
CR201	1	Rectifier,Stack	Kepco Inc.	124-0140
CR202	1	Rectifier,Silicon,Pigtail	Automatic PT-5	124-0028
DS101	1	Pilot Light	General Elec. NE-51	153-0024
F101	1	Fuse,Instantaneous	Bussman AGC-1	141-0015
L201	1	Choke	Kepco Magnetics 100-1305	100-1305
*M101	1	Meter 0 -100A 2½"	General Elec. 8DW91A	135-0231
*M102	1	Meter 0-10V, 2½"	General Elec. DW91	135-0232
R101	1	Resistor,Variable,Multiturn 75 ohm, 3W	Spectrol 510	115-1251
R102	1	Resistor,Variable,Multiturn 800 ohm, 3W	Spectrol 510	115-1252
R201	1	Resistor,Power Strip 300 ohm, 10W	Hardwick Hindle BR56-300	115-1141
R202	1	Resistor,Power Strip 50 ohm, 10 W	Ohmite F111	115-0865
R203	1	Resistor,Power Strip 2.5K, 10 W	Hardwick Hindle BRS56,B361	115-1089
R204	1	Resistor,Power Strip 250 ohm, 20 W	Ward Leonard 20 S, 250	115-0604

*Metered Models only

REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
R205	1	(Same as R204)		
R206	1	Resistor,Power Strip 10 ohm, 20 W	Ward Leonard 20 S10	115-0727
R207	1	Resistor,Power Strip 100 ohm, 20 W	Ward Leonard 20 S100	115-0651
R208	1	Resistor,Power Strip 1.5 ohm, 55 W	Ward Leonard 555S1.5	115-0711
R209	1	Resistor,Power Strip 50 ohm, 55 W	Ward Leonard 55 S50	115-0629
R210	1	Resistor, Deciohm 0.006 ohm, 60 W	Kepco, Inc. 115-1295	115-1295
R212	1	Resistor,Fixed Molded 10 ohm, ½ W	Allen Bradley EB1001	115-0502
RL201	1	Relay 3PDT	Omega Elec. 200 PC 3CX	140-0040
T201	1	Transformer,Power	Kepco Magnetics 100-1304	100-1304
T301	1	Transformer,Reference	Kepco Magnetics 100-1306	100-1306
Transistor Assembly:				
A911	1	Driver Assembly Includes the following:	Kepco, Inc.	110-0162
	2ea.	Transistor,PNP	Delco	**119-0016
	2ea.	Resistor,Fixed Molded 33 ohm, ½ W	Allen Bradley EB3301	115-0681
A901-904 A906-907 A909,A910	8	Pass Assembly Includes the following:	Kepco, Inc.	110-0163
	2ea.	Transistor, PNP	Delco	**119-0016
	2ea.	Resistor,Fixed Power 0.2 ohm, 12.5W	Hardwick Hindle ZA46-1	115-1156
R211	1	Resistor, Power Strip 5 Ohm, 65 W	Hardwick Hindle 4-3/4BR 35-5-5	115-1139

** See Field Replacement Page.

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
Transistor Assembly Cont:				
A905 A908	2	Pass Assembly Includes the following:	Kepco, Inc.	110-0164
	1ea.	Thermostat N.O. 80°C	Chatham Control	127-0165
	2ea.	Resistor, Power Axial 0.2 ohm, 12.5W	Hardwick Hindle ZA4.6-1	115-1156
	2ea.	Transistor, PNP	Delco	**119-0016
*R301	1	Resistor, Variable WW 100 Ohm, 2 W	Clarostat 43C2-100	115-0436
*R302	1	Resistor, Fixed, WW 100 Ohm, 3 W	Ward Leonard 3X100	115-0471

*Metered Models Only.

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
C1	1	Capacitor,Electrol. Pigtail 350 µf, 50 V	Industrial Cond. 1B844	117-0114
C2	1	Capacitor,Electrol, Pigtail 100 µf, 25 V	Sprague Elec. TE1211	117-0289
C3, 24	2	Capacitor,Electrol. Pigtail 25 µf, 25 V	Industrial Cond. 1B1063	117-0105
C4, 8, 10, 12	4	Capacitor,Fixed, Mylar 2 µf, 200 V	Hopkins Eng. 2P2MK	117-0129
C5, 7,	2	Capacitor,Electrol.Pigtail 1 K µf, 6 V	Industrial Cond. 1B1382-RM	117-0346
C6	1	Capacitor,Fixed, Mylar 1 µf 200 V	Hopkins Eng. 1P2MK	117-0207
C9, 11, 14	3	Capacitor,Fixed, Mylar 0.1 µf, 200 V	Hopkins Eng. P12M	117-0363
C15, 20, 21	3	Capacitor,Fixed, Mylar 0.05 µf, 200 V	Hopkins Eng. P052M	117-0315
C16, 17	2	Capacitor,Fixed, Mylar 0.05 µf, 400 V	Hopkins Eng. P054M	117-0367
C18	1	Capacitor,Electrol. Pigtail 1 K µf, 10 V	Industrial Cond. RMVS Type	117-0176
C19	1	Capacitor,Electrol. Pigtail 500 µf, 50 V	Industrial Cond. 1B1163-RM	117-0221
C22, 23	2	Capacitor,Electrol. Pigtail 500 µf, 60 V	General Elec. 43F2645-AA1	117-0356
CR1,2,4,5, 13,14	6	Rectifier,Silicon,Pigtail	Columbus CEC105	124-0133
CR3	1	Zener Diode	Hoffman 1N429	121-0001
CR6,11,12, 15 to 18	7	Rectifier,Silicon,Pigtail	Automatic PT5	124-0028
CR7	1	Zener Diode	Motorola 1.5 M25	121-0024
CR8	1	Zener Diode	Tung-Sol 1N1355	121-0035
CR9	1	Zener Diode	Transitron Elec. SV-125	121-0028
CR10	1	Zener Diode	Texas Inst. 1N1822	121-0004

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
Q1 4,7,8, 10,12,13	9	Transistor, NPN	General Trans. 119-0024	119-0024
Q5,9,11,14 16,18,19 21	8	Transistor, PNP	Tung-Sol I19-0022	**119-0022
Q6,17	2	Transistor, PNP	Delco 119-0034	**119-0034
Q20	1	Transistor, Unijunction	General Elec. I19-0048	**119-0048
R1	1	Resistor,Power,Axial,LTC 750 ohm 1 W	Tepro Elec. TS1W	115-1247
R3	1	Resistor,Power Axial 5 K ohm 3 W	Hardwick Hindle GA747	115-1094
R4,11,24	3	Resistor,Fixed,Molded 2.7 K ohm, ½ W	Allen Bradley EB2721	115-0560
R5,6	2	Resistor, Power, Axial 2.25 K ohm, 3 W	Hardwick Hindle 741	115-1115
R8, 10	2	Resistor,Fixed, Molded 39 ohm ½ W	Allen Bradley EB3901	115-0623
R9	1	Resistor,Fixed,Molded 56 K ohm ½ W	Allen Bradley EB5635	115-0255
R12,44	2	Resistor,Fixed, Molded 560 ohm ½ W	Allen Bradley EB5615	115-0888
R13	1	Resistor,Fixed, Molded 47 ohm, 1 W	Allen Bradley GB4701	115-0005
R14,25,47	3	Resistor,Variable,Wire Wnd. 500 ohm ½ W	Bourns Inc. 3367P-1-501	115-1171
R16,2,7, 15	4	Resistor,Power, Axial 500 ohm 1 W	Tepro Elec. TS1W	115-1248
R17	1	Resistor,Power, Axial 12.5 K ohm 1 W	Tepro Elec. TS1W	115-1241
R18	1	Resistor,Fixed, Molded 10 K ohm ½ W	Allen Bradley EB 1035	115-0249
R19	1	Resistor,Fixed, Molded 13 K ohm ½ W	Allen Bradley EB 1335	115-0920
R20	1	Resistor,Fixed, Molded 3.9 K ohm ½ W	Allen Bradley EB 3925	115-0808

**See Field Replacement Page

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
R21,27,54, 55	4	Resistor,Fixed, Molded 100 ohm ½ W	Allen Bradley EB1015	115-0341
R22	1	Resistor,Fixed, Molded 15 K ohm ½ W	Allen Bradley EB1535	115-1025
R23	1	Resistor,Fixed, Molded 1200 ohm ½ W	Allen Bradley EB1225	115-1167
R26	1	Resistor,Fixed, Molded 620 ohm ½ W	Allen Bradley EB6215	115-0565
R29,49	2	Resistor,Fixed, Molded 4.7 K ohm ½ W	Allen Bradley EB4721	115-0467
R30	1	Resistor,Power, Axial 10 ohm 3 W	Hardwick Hindle 9/16 GA-10-LTC	115-1160
R31	1	Resistor,Power, Axial 20 K ohm 1 W	Tepro Elec. TS1W	115-1240
R32	1	Resistor,Fixed, Molded 5.6 K ohm ½ W	Allen Bradley EB5625	115-0559
R33	1	Resistor,Fixed, Molded 82 ohm ½ W	Allen Bradley EB8205	115-1243
R34,51,52	3	Resistor,Fixed, Molded 1 K ohm ½ W	Allen Bradley EB1021	115-0547
R35,46	2	Resistor,Fixed, Molded 2.2 K ohm ½ W	Allen Bradley EB2221	115-0466
R36	1	Resistor,Fixed, Molded 360 ohm ½ W	Allen Bradley EB3615	115-1164
R37	1	Resistor,Fixed, Molded 330 ohm ½ W	Allen Bradley EB3315	115-1086
R38,53	2	Resistor,Fixed, Molded 470 ohm ½ W	Allen Bradley EB4715	115-0919
R39	1	Resistor,Fixed, Molded 33 K ohm ½ W	Allen Bradley EB3331	115-1127
R40	1	Resistor,Fixed, Molded 68 K ohm ½ W	Allen Bradley EB6805	115-0904
R41	1	Resistor, Fixed, Molded 6.2 K ohm 1 W	Allen Bradley GB6225	115-1244
R42	1	Resistor,Power, Axial 1250 ohm 5 W	Hardwick Hindle 1WA	115-1245
R43	1	Resistor,Power, Axial 5 ohm 5 W	Ward Leonard 5X5	115-0516

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SCHEMATIC NO.	QTY.	DESCRIPTION	MFRS. NAME & PART NO. (See Note)	KEPCO PART NO.
R45	1	Resistor,Fixed, Molded 1.5 K ohm ½ W	Allen Bradley EB1521	115-0578
R48	1	Resistor,Fixed, Molded 22 ohm ½ W	Allen Bradley EB2205	115-1282
R50	1	Resistor,Fixed, Molded 330 ohm ½ W	Allen Bradley EB3311	115-0804
R58	1	Resistor,Power, Axial 680 ohm 3 W	Hardwick Hindle 9/16 GA 680	115-1250
R59	1	Resistor,Fixed, Molded 10 ohm ½ W	Allen Bradley EB1005	115-0818
C13	1	Capacitor,Electrol.,Pigtail 2.5 K μf, 10 V	General Electric GE 43F 2516A-A1	117-0345
C25	1	Capacitor,Mylar Film 0.01 μf, 200 V	Sprague 192P10302	117-0353

REPLACEMENT PARTS MAY BE ORDERED FROM KEPCO, INC. ORDERS SHOULD INCLUDE KEPCO PART NUMBER AND DESCRIPTION.

PLEASE NOTE: THE MANUFACTURER'S NAME AND PART NUMBER LISTED FOR EACH ITEM ON REPLACEMENT PARTS LISTS, REPRESENTS AT LEAST ONE SOURCE FOR THAT ITEM AND IS LISTED SOLELY FOR THE CONVENIENCE OF KEPCO EQUIPMENT OWNERS IN OBTAINING REPLACEMENT PARTS LOCALLY. WE RESERVE THE RIGHT TO USE EQUIVALENT ITEMS FROM ALTERNATE SOURCES. KEPCO, INC.

FIELD REPLACEMENT LIST

Kepco Part No.	Description	Recommended Replacement MFR.	Mfr. No.
119-0003 119-0016	Transistor PNP	Delco	2N174
119-0022	Transistor PNP	Tung-Sol	2N382 2N1707
119-0034	Transistor PNP	Delco	2N1172
119-0035, 0036,0037	Transistor PNP	Motorola Clevite	2N1167 CTP 3553
119-0048	Transistor Unijunction	General Elec.	2N1671A
119-0020	Transistor PNP	RCA	2N398A
119-0038	Silicon NPN	Transitron	ST29
119-0004	Transistor PNP	Delco	2N277
119-0024	Transistor NPN	Gen. Instrument RCA Sylvania	2N1605 2N388 2N1308

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